REMARKS

Claims 19-52 and 119-127 are all the claims presently pending in the application.

Claims 19-36 and 119-121 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Sayyah ("A Study of Growth Mechanisms and Electrical and Optical Properties of Epitaxial $Al_xGa_{1-x}N$ Layers Grown by Atmospheric Pressure Metalorganic Chemical Vapor Deposition", A Dissertation Presented to the Faculty of the Graduate School, University of Southern California, February 1986). Claims 37-52 and 122-127 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Sayyah.

These rejections are respectfully traversed in view of the following discussion.

I. THE CLAIMED INVENTION

The claimed invention (e.g., as recited in claim 19) is directed to a method for producing a gallium nitride group compound semiconductor by using an organometallic compound vapor phase epitaxy. The inventive method includes <u>setting a mixing ratio</u> of a silicon-containing gas to at least one other raw material gas at a desired value <u>in a range over which a conductivity of the gallium nitride group compound semiconductor increases substantially proportionally with the mixing ratio</u> so as to obtain a desired conductivity (1/resistivity) of the gallium nitride group compound semiconductor, and forming the gallium nitride group compound semiconductor by feeding the silicon-containing gas and the at least one other raw material gas at the mixing ratio.

In another aspect (e.g., as recited in claim 20), the inventive method includes <u>setting a mixing ratio</u> of a silicon-containing gas to at least one other raw material gas at a desired value <u>in a range over which a carrier concentration of the gallium nitride group compound semiconductor increases substantially proportionally with the mixing ratio</u> so as to obtain a desired carrier concentration of the gallium nitride group compound semiconductor, and forming the gallium nitride group compound semiconductor by feeding the silicon-containing gas and the at least one other raw material gas at the mixing ratio.

Conventional methods do not <u>set a mixing ratio</u> of a silicon-containing gas to at least one other raw material gas during the vapor phase epitaxy at a desired value <u>in a range</u>

over which conductivity (e.g., or a carrier concentration) of the gallium nitride group compound semiconductor increases substantially proportionally with the mixing ratio.

The claimed method, on the other hand, includes setting a mixing ratio of a silicon-containing gas to at least one other raw material gas at a desired value in a range over which a conductivity (e.g., carrier concentration) of the gallium nitride group compound semiconductor increases substantially proportionally with the mixing ratio.

The inventive method enables a production of a gas-phase grown GaN layer of high purity. That is, it provides an n-type GaN layer with high resistivity without requiring a doping with impurities, unlike conventional technology which provides n-type GaN with low resistivity when no doping is performed.

II. THE SAYYAH REFERENCE

The Examiner alleges that Sayyah teaches the invention as recited in claims 19-36 and 119-121, and makes obvious the invention as recited in claims 37-52 and 122-127. Applicant submits, however, that there are elements of the claimed invention that are not taught or suggested by Sayyah.

Sayyah discloses factors influencing the properties of epitaxial layers of $Al_xGa_{1-x}N$ grown on sapphire substrates by an atmospheric pressure metallorganic chemical vapor deposition (MOCVD) technique (Sayyah at page 162).

However, Applicant submits that Sayyah does not teach or suggest a method for producing a gallium nitride group compound semiconductor by an organometallic compound vapor phase epitaxy, where the method includes setting a mixing ratio of a silicon-containing gas to at least one other raw material gas at a desired value in a range over which a conductivity (e.g., or a carrier concentration) of the gallium nitride group compound semiconductor increases substantially proportionally with the mixing ratio, as claimed, for example, in claims 19-20.

Specifically, Applicant respectfully submits that Sayyah does not disclose or suggest that electron concentration increases in proportion to gas including Si.

That Si forms donor level is different from that electrons are excited to the conduction

band. Sayyah does not measure the characteristic which increases electron concentration. Instead, Sayyah discloses that electron concentration does not increase even by doping Si.

That is, in Sayyah's "Dissertation Abstracts International Vol. 47 No. 06 1986" and its Dissertation "A Dissertation Presented to the FACULTY OF THE GRADUATE SCHOOL UNIVERSITY OF SOUTHERN CALIFORNIA `A STUDY OF GROWTH MECHANISMS AND ELECTRICAL AND OPTICAL PROPERTIES OF EPITAXIAL $Al_xGa_{1-x}N$ LAYERS GROWN BY ATOMOSPHERIC PRESSURE METALORGANIC CHEMICAL VAPOR DEPOSITION', February 1986", which had been filed as an IDS document, clearly show that even when silicon is doped in $A1_xGa_{1-x}N$ to a doping concentration of $8 \times 10^{21}/cm^3$, conductivity of $Al_xGa_{1-x}N$ cannot be changed.

In the Dissertation page 135, lines 18-22, it is disclosed that even if silicon is doped in $A1_xGa_{1-x}N$ having comparatively high molar fraction of aluminum, conductivity of a film was not changed from semiinsulative to conductive. It is also disclosed that when $1.4 \times 10^{21}/cm^3$ and $8.0 \times 10^{21}cm^{-3}$of silicon were doped in $A1_xGa_{1-x}N$ having aluminum composition ratio x of 0.56 and 0.81, respectively, any measurable conductivity cannot be observed.

Further, Applicant respectfully submits that although Si may be doped during crystal growth in Sayyah's method, the Si is not doped for controlling electron conductivity.

That is, Sayyah et al discloses in FIG. 27 that SiH_4 / (TMG + TMA) ratio is in a range of 0 to 0.1. This ratio, however, does not control conductivity or electron concentration. Sayyah only teaches that uptake quantity of Ga and Al varies according to doping quantity of Si.

Applicant further points out that at the time when the present invention was filed, Si had been recognized as an **acceptor** impurity.

In Table I of page 4 of Tietjen et al's "Vapor Phase Growth Technique and System for Several III-V Compound Semiconductors", March 1969, Electronics Research Center Cambridge, Massachusetts National Aeronautics and Space Administration, which had been filed as an IDS document, undoped GaN has electric concentration from $3.0 \times 10^{19}/cm^3$to 6.7 x $10^{19}/cm^3$. By doping silicon to the undoped GaN, as shown in Table II of page 4, electron concentration of GaN decreases to a range of $2.0 \times 10^{19}/cm^3$to $3.0 \times 10^{19}/cm^3$.

The fact that the electron concentration decreases even when silicon is doped means that silicon has ability to capture electrons. So silicon clearly behaves as an acceptor impurity. In addition, Table II is titled "Electrical Properties of GaN Doped With Acceptor Impurities," which makes clear that silicon was clearly recognized as acceptor at the time when the present invention was invented. Accordingly, Tietjen also shows that silicon does not behave as donor but behaves as acceptor in a gallium nitride compound semiconductor.

On the contrary, as disclosed in a paragraph starting from line 24 on page 15 in the original specification, electron concentration of the non-doped GaN is 1 x $10^{15}/cm^3$ in the present invention. That disclosure proves that when electron concentration is 1 x $10^{15}/cm^3$ or more, electron concentration can be controlled linearly according to Si concentration as shown in the graph attached hereto as Exhibit A. Clearly, Sayyah never teaches or suggests such characteristics.

In summary, as explained above, at the time when the present invention was invented, when silicon is doped to the GaN based compound semiconductor, electron concentration cannot be increased linearly at a room temperature as shown in Figure 28 of the present Application.

IV. FORMAL MATTERS AND CONCLUSION

In view of the foregoing, Applicant submits that claims 19-52 and 119-127 all the claims presently pending in the application, are patentably distinct over the prior art of record and are in condition for allowance. The Examiner is respectfully requested to pass the above application to issue at the earliest possible time.

Should the Examiner find the application to be other than in condition for allowance, the Examiner is requested to contact the undersigned at the local telephone number listed below to discuss any other changes deemed necessary in a telephonic or personal interview.

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The Commissioner is hereby authorized to charge any deficiency in fees or to credit any overpayment in fees to Attorney's Deposit Account No. 50-0481.

Respectfully Submitted,

Date: 7/21/04

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